Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
	)	
Service Rules for the 746-764 and 776-794 MHz Bands, and Revision to Part 27 of the Commission's Rules	)	WT Docket No. 99-168

To: The Commission

COMMENTS OF THE CONSUMER ELECTRONICS MANUFACTURERS ASSOCIATION

Gary S. Klein
Vice President,
Government and Legal Affairs

Michael Petricone
Director, Technology Policy
Government and Legal Affairs

George Hanover
Staff Vice President
Technology & Standards

Ralph Justus
Director
Technology & Standards

2500 Wilson Boulevard
Arlington, Virginia 22201
(703) 907-7600

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SUMMARY

In this proceeding, the Commission seeks comment on its proposals to adopt service rules to permit new services – such as a variety of wireless and broadcasting services -- in the 746-764 MHz and 776-794 MHz bands. CEMA believes that this proceeding presents an exciting and historic opportunity for the Commission, for broadcasters, for receiver and transmitter equipment manufacturers, and mostly for the American public. In CEMA's view, using the frequency bands under consideration in this proceeding are ideal to create a new terrestrial "Mobile Multimedia Broadcast Service" (hereinafter referred to as "MMBS").

CEMA presents a "concept design" that describes the capability of MMBS to:

(1) provide a plethora of services, free and over-the-air, high quality, multi-channel audio programming, news and information services, and importantly high-capacity data services, with seamless, robust and interference-proof reception in the mobile environment;

(2) transmit in spectrum efficient multiplexed "ensembles" of five or more program and data channels which offers a novel opportunity for licensing;

(3) offer broadcasters an opportunity to participate in the digital revolution with a high quality, high-capacity service;

(4) present "scalable" reception opportunities to consumers whereby their costs/value assessments determine whether they purchase equipment capable of receiving the full complement of 5.1 channel audio, at CD+ quality, and a host of data features and services, or (at another extreme) simply monophonic reduced-quality audio reception or simple data services; and

(5) maximize government revenues from potential future auction of this spectrum.

CEMA envisions that these objectives can be achieved, but recognizes that the Commission ultimately must decide whether creation of MMBS is sufficiently in the public interest. In CEMA's view, creation of MMBS is in the public interest, and suggests below a structure for the Commission to develop a process sufficient to accomplish the creation of this new broadcast

service. CEMA urges the Commission to:

(1) Determine that the public interest use of this spectrum is best served by designating it exclusively for MMBS.

(2) Create and empower an Advisory Committee to

(a) evaluate, assess and integrate the appropriate available technologies meeting well-defined criteria, and propose a single MMBS system for Commission adoption; and

(b) structure the regulatory and administrative licensing paradigm that maximizes the features, quality and services available from MMBS and its attraction to broadcasters, while minimizing the regulatory burden on Commission resources.

(3) Establish the appropriate auction process and implementation only after defining the technology to be deployed for MMBS and the service rules and regulations necessary to define the service.

CEMA pledges its strong support to further this initiative.

Finally, CEMA believes that the Commission cannot find it in the public interest to exclude the development of MMBS through the application of generic Part 27 rules that would open this spectrum to a variety of incompatible uses and preclude the development of a new, national mass media market.

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To: The Commission

COMMENTS OF THE CONSUMER ELECTRONICS MANUFACTURERS ASSOCIATION

The Consumer Electronics Manufacturers Association ("CEMA"), pursuant to Section 1.415 of the Commission's Rules, 47 C.F.R. § 1.415, hereby respectfully submits its comments in response to the Notice of Proposed Rulemaking ("NPRM")[1] issued by the Commission in the above-captioned proceeding.

I. INTRODUCTION AND STATEMENT OF INTEREST

CEMA, a sector of the Electronics Industries Alliance, is the principal trade association of the consumer electronics industry. CEMA members design, manufacture, distribute and sell a wide variety of consumer electronics products that span the audio, video, mobile electronics, communication, information technology, integrated home systems and accessories markets. Its

[1] *In the Matter of Service Rules for the 746-764 and 776-794 MHz Bands, and Revisions to Part 27 of the Commission's Rules*, WT Docket No. 99-168, Notice of Proposed Rulemaking, FCC 99-97 (June 3, 1999) ("*NPRM*").

membership includes most major manufacturers of consumer electronics products as well as smaller companies that design, produce, distribute and service consumer electronics products. As such, CEMA has an interest in the Commission's proposal to permit use of the spectrum bands in question for mass media services and other new products, opening the electronics manufacturing industry to new product opportunities.

In the NPRM, the Commission proposes to adopt service rules to permit new services on spectrum bands formerly designated exclusively for the UHF television broadcast service. The Commission states that these spectrum bands could be used potentially for a variety of wireless or broadcasting services. The availability of this spectrum is the result of the Commission's efforts to free up channels 60-69 for new users as part of the transition to digital television ("DTV"). The 746-764 MHz and 776-794 MHz bands have been used by television stations on channels 60-62 and 65-67. The Commission notes that Congress directed, in the Balanced Budget Act of 1997, that this 36 megahertz of spectrum be reallocated and auctioned for commercial purposes, and specified that the auction take place after January 1, 2001. The Commission also notes that after the auction and licensing of successful bidders for these commercial bands, existing full power UHF licensees will be permitted to continue operations protected from interference until the deadline for conversion to DTV. The NPRM seeks comment on a wide range of technical and regulatory issues, including issues that arise from the possible use of these bands for both commercial wireless and broadcasting services.

CEMA strongly supports the Commission's efforts to adopt service rules that will permit new services on spectrum bands formerly designated exclusively for the UHF television broadcast service. In this proceeding, CEMA has interest in ensuring that, within the Commission's statutory obligations, the available spectrum is assigned to meet its best and most

appropriate use. In CEMA's view, using the frequency bands under consideration in this proceeding are ideal to create a terrestrial "Mobile Multimedia Broadcast Service" (hereinafter referred to as "MMBS").

II. THE COMMISSION SHOULD USE THE 746-764 AND 776-794 MHz BANDS TO CREATE A NEW MOBILE MULTIMEDIA BROADCAST SERVICE ("MMBS").

This proceeding presents, in CEMA's view, an exciting and historic opportunity for the Commission, for mass media entities, for receiver and transmitter equipment manufacturers, and mostly for the American public. CEMA believes that using the frequency bands under consideration in this proceeding are ideal to create a new terrestrial Mobile Multimedia Broadcast Service, the concept design and performance objectives of which are described below.

A. This Proceeding Presents the Commission With an Historic Opportunity to Create a New Broadcast Service Meeting Public Needs for the Next Millennium.

Extensive participation by CEMA and its members in past Commission proceedings leads CEMA to conclude that a significant gap exists in providing new digital broadcast services to the public – *i.e.*, mobile reception. Free, over-the-air reception by the public of high-quality digital audio, information, and high-capacity data services can and should be provided for mobile reception. The technologies exist to do so. Before this proceeding, adequate and appropriately placed radiofrequency spectrum was not available for its design and implementation. CEMA believes, however, that the 740-764 MHz and 776-794 MHz frequency bands are ideally placed and provide enough bandwidth to create a successful nationwide MMBS.

The extensive digital television proceeding has given analog television broadcasters the opportunity to provide High Definition Television ("HDTV"), multiplexed Standard Definition

Television ("SDTV"), and program-related and ancillary data services sufficient to meet their needs for the next generation. Satellite digital audio radio licensees are expected to initiate their services shortly, but largely on a subscription basis. Terrestrial radio broadcasters have focused on developing "in-band/on-channel" ("IBOC") technologies (that actually place digital signals in the first-adjacent spectrum channel to the "host" analog station). It remains to be demonstrated, however, that an IBOC approach can provide compact disc ("CD") audio quality, compatibly, with robust coverage and performance – features that CEMA believes are critical to widespread consumer acceptance.[2]

Participating in these past proceedings, and other activities over the past few years has developed our collective understanding of what digital technologies are capable of and the types of multi-media services that can be successfully broadcast and received, as well as a deeper recognition of those services desired by consumers. For the next generation broadcasting system, CEMA believes that much more than audio programming is required. MMBS presents an opportunity to meet these needs successfully.

B. Basic Performance Objectives for MMBS

CEMA's members have considered the potential capabilities of MMBS extensively and offer the following as a starting point for defining appropriate performance objectives.

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[2] As CEMA conveyed in its Comments in response to USA Digital Radio Partners, L.P.'s petition for rulemaking to permit the introduction of terrestrial audio radio in the AM an FM radio bands, CEMA's past evaluations of proposed IBOC DAR technologies revealed that their potential implementation would have caused an unacceptable degradation of the reception "host" station transmitters as well as interference to other stations. *See* CEMA Comments in RM-9395 (filed Dec. 23, 1998). Further, CEMA pointed out that due to the existing congested occupancy of the AM and FM bands, it was determined that analog-to-digital interference would severely limit potential IBOC DAR digital coverage. CEMA believes that these deficiencies must be overcome if the new versions of IBOC DAR are to form the basis for the provision of digital radio service in the United States.

1. multi-channel capacity with CD or better audio quality

DTV and Digital Versatile Disc (DVD) will shortly become ubiquitous and will provide the public with the multi-channel listening experience of discrete 5.1-channel (left, center front, right, left rear, right rear and sub-woofer) CD-quality audio heretofore only experienced in theaters. This, CEMA believes, is what consumers of the future will expect in audio services – CD (or higher) audio quality with multi-channel capability. CEMA's market research shows that, already, 80% of consumers say they would choose music CDs with a surround sound experience similar to a movie theater over current CDs.

Newer versions of source coding technologies (*e.g.*, Dolby Digital, Lucent PAC, and MPEG-AAC) promise far more efficient coding with CD or higher audio quality and are adaptable for multichannel service. It is apparent to CEMA and its members that a new broadcast service that provides anything less than CD-quality has questionable appeal to listeners. "Near CD quality" or "better than FM quality" (as has been discussed by DAR system proponents) simply falls short of the quality of service consumers have come to expect. This is especially true if they are faced with the prospect of investing in the purchase of new receivers. Coupling CD-quality with multi-channel audio capabilities is essential, in CEMA's opinion, to meet listener expectations.

2. robust mobile reception capability

Americans are increasingly mobile and their appetites for mobility in their electronics for telephony, entertainment, information, and data services are well established. CEMA's market research reveals that 44% of households own a wireless phone; 14% of consumers use a notebook or laptop computer on a regular basis at home or on the job; and that 6% of consumers own a Palm Pilot, Win CE device, or other type of hand-held PC on a regular basis at home or at

work. Furthermore, CEMA's research indicates that consumers, working full or part-time, find important having remote access to office E-mail (40%), voicemail (49%), and files on their computer network (37%). CEMA believes that these findings represent a leading indicator of the importance of mobility in new electronic services and, by extension, to the requirement that MMBS be designed primarily for mobile reception. If that is accomplished, and the correct frequency band is used, stationary and home reception is assured.

At the same time, CEMA recognizes that the mobile reception environment is one of the most demanding technical challenges to overcome. Past studies have demonstrated the advantages of coded orthogonal frequency division multiplexed ("COFDM") modulation to overcome difficult mobile multipath reception environments successfully.[3]

In the Commission's consideration of COFDM, CEMA appends to these comments a study ("CRC Report") it commissioned in 1997, which examines the mobile reception environment and capabilities of COFDM at different frequency bands.[4] A copy of this study was filed along with CEMA's Comments in IB Docket No. 95-91.[5] This study analyzes the 1452-1492 MHz and 2310-2360 MHz frequency bands, various digital modulation and coding technologies, and the effects of (and digital coding designs to overcome) mobile multipath

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3 CEMA believes its consideration here of COFDM modulation is appropriate and distinct from other arenas (*e.g.*, DTV) since CEMA's vision for MMBS is a service with vastly different offerings intended for robust mobile reception.

4 *See* Appendix A: G. Chouinard, B. McLarnon, R. Paiement, *et al.*, "Analysis of the Technical Merits of Terrestrial Gap-Fillers Supplementing DAR Satellite Broadcasting in the L-Band and S-Band Frequency Range" (May 21, 1997) ("*CRC Report*").

5 *See* Commission record in *Establishment of Rules and Policies for the Digital Audio Radio Satellite Service in the 2310-2360 MHz Frequency Band*, IB Docket No. 95-91; GEN Docket No. 90-357 (RM No. 8610, PP-24, PP-86, PP-87), Report and Order, Memorandum Opinion and order, and Further Notice of Proposed Rulemaking, 12 FCC Rcd 5754 (1997).

impairments. Importantly, the CRC Report also discusses a relationship between digital coding technologies, their performance, and the frequency band of operation.[6] Further, this study identifies the 700-800 MHz frequency range as an ideal spectrum candidate to implement terrestrial digital technologies akin to MMBS – the very subject frequencies of this proceeding.[7]

CEMA believes that mobile reception is an important consideration not only for continuity of audio entertainment programming, but also for the provision of data services. The Intelligent Transportation Services, radio IP concepts and other high-capacity data services and industries yet to be devised, can all benefit from the capability of MMBS to achieve seamless, interference-free mobile reception.

3. high-capacity data services

MMBS offers the ability to design a broadcast service with high-capacity data capabilities to provide program-related and ancillary services. For example, the Radio Broadcast Data Service ("RBDS") provides 1200 bps data for a host of program-related text messages, automatic tuning, emergency alert functions, and other services. High-speed FM Subcarrier broadcast systems offer up to16 kpbs data capacity. But there is no reason, other than spectrum availability, why data rates up to or higher than 64 kpbs could not be considered, designed into MMBS and deployed for a multitude of services for both free and subscription offerings. This,

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6 *See* Appendix A, *CRC Report* at § 7.

7 While the *CRC Report* was prepared and filed in a different context (*i.e.*, hybrid satellite/terrestrial DAR), the terrestrial analyses therein, nonetheless, are valid and germane to the instant proceeding.

coupled with robust mobile reception, could spawn the creation of services to the public we have not yet even considered.[8] These opportunities deserve further study and development.

For example, the data delivery capabilities of the proposed MMBS can be a valid piece in the puzzle of how to deliver traffic and safety-related information to vehicles utilizing a single standard that can be used nationwide. It can be anticipated that mobile receivers designed for this service would include a "data port" as well as audio outputs. This feature, when combined with the Intelligent Transportation System Data Bus ("IDB") in vehicles, provides the means of delivering multiple types of data to the motorist. This can be general "broadcast" data related to weather, safety, and road conditions or "addressable" data to an individual or group.

Another aspect of MMBS data service is the potential for delivering emergency data, such as hazardous weather conditions, evacuation warnings, and other lifesaving messages to the specific areas that are threatened. MMBS home receivers could offer the capability to be addressable – *i.e.*, by county and/or ZIP code – and also be designed to monitor this "emergency data channel" when in an OFF state, automatically generating an alert when an emergency message is received. This would be an effective digital extension to the current Emergency Alert System required of current broadcast services.

Thus, "multi-media" broadcasting can be created which extends by an order of magnitude the service offerings considered practical in the past. Further, if the data rate available in MMBS can be flexibly distributed over different program/data channels (with the

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[8] Examples of these services can encompass: electronic program guides; dynamic content such as stock exchange quotes; still pictures (maps) accompanying navigation information; intelligent transportation services such as traffic information; emergency alert messages; electronic books and newspapers; advertising, games, and software updates; and animate video.

use of the COFDM ensemble structure), the data capacity can be dynamically changed depending on service offerings and requirements.

4. scalable reception capability

A packet-based design of the MMBS data protocol offers the capability to design and produce a wide range of service and hardware products meeting a variety of consumer needs. For example, the MMBS transmission could be received on a top-of-the-line receiver that provides full multi-channel audio and data service functionality. Furthermore, more modest receivers could be monophonic, stereophonic, employ aggressive compression for subsequent storage and retrieval, or targeted even for an individual data service – or anywhere between these extremes – based upon the consumers' desire to invest in a new receiver and the service offerings.

5. flexible data tags

Program associated data can easily be incorporated with MMBS using flexible data tags to allow information such as "artist," "song title," "CD source," cost, availability, promotions and programming linked to other sources. In this respect, it would be advantageous to use existing protocols (*i.e.*, RBDS tags such as AF, M/S, PI, PTY, PTYN, TA, TDC, TMC and TP)[9] to achieve as much commonality as possible with other such systems.

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[9] AF (alternative frequencies list), M/S (music/speech switch), PI (program identification), PTY (program type), PTYN (program type name), TA (traffic announcement identification), TDC (transparent data channels), TMC (traffic message channel), and TP (traffic program identification).

C. Concept Design of MMBS and Spectrum Implications

CEMA offers this analysis of technologies it believes appropriate to use as models for constructing an illustrative "concept design" of MMBS to derive spectrum requirements and other issues to serve as a focus on many of the issues raised in the Notice.

Past studies have examined digital audio radio systems and the inter-relationship of the RF signal bandwidth occupied by the compressed audio signal, the compressed audio bit rate transmitted, ancillary data transmission data rates, error protection codes, and subsequent power efficiency of the overall system (a function of both the power efficiency of its channel coding and modulation subsystem) to determine the overall spectral efficiency.[10] These studies have shown that systems with a spectral efficiency of 0.80 bits/second/Hertz or lower had the higher level of performance, when operating under mobile multipath fading channels.[11] CEMA believes it appropriate to apply this value for this assessment.

The six television channels under consideration provide a potential 36 MHz RF bandwidth. When the spectral efficiency of 0.8 bits/s/Hz is applied, this yields a total data capacity of 28.8 Mbps. Assume also that, for example, 320 kbps/program channel can provide 5.1 multichannel audio with CD quality sound (*e.g.*, AAC), including 10% transmission coding and error correction. Finally, add a requirement for 64 kpbs ancillary data capacity in addition to each program channel and a total of 384 kpbs per program/data channel is determined. Consequently, the total 36 MHz RF spectrum could be devised to provide up to 75 independent

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10 "EIA/NRSC DAR Systems Subjective Tests, Part II: Transmission Impairments," Thibault, G. Soulodre, and T. Grusec, IEEE Transactions on Broadcasting, Vol. 43, Number 4, December 1997, 363-364 and Appendix B.

11 This is a conservative value based on the performance of various systems tested in the 1994-1996 period.

program/data channels. If this were further developed into a multiplexed "ensemble" structure of five program/data channels per ensemble, then up to 15 separate ensembles could be constructed for MMBS, and this could be the basis for a licensing regimen. CEMA recognizes, of course, that further detailed analysis is needed to optimize the COFDM modulation for this particular frequency band (symbol duration, number of carriers, carrier spacings, guard interval, etc.) as well as the optimal RF ensemble bandwidth. Nonetheless, the foregoing analysis provides an overview of what may be achievable.

D. CEMA Proposal for Establishing MMBS

CEMA urges the Commission to consider the public interest benefits of establishing a new Mobile Multimedia Broadcast Service and offers the following suggestions to structure an appropriate venue to achieve this. First, CEMA urges the Commission to designate the entire 36 MHz (746-764 MHz and 776-794 MHz bands) to create a new MMBS, with the assumption that the Commission must specify the technical standards and system to be deployed. Second, CEMA encourages the Commission to form and empower a government/industry Advisory Committee to develop these requirements further, to assess, evaluate and integrate the appropriate available technologies meeting well-defined criteria, and to recommend a single MMBS standard for Commission adoption.[12] Further, the Advisory Committee should recommend a structure for the regulatory and administrative licensing paradigm that maximizes the features, quality and services to the public available from MMBS and its attraction to broadcasters and manufacturers, while minimizing the regulatory burden on Commission resources. Finally, and only after dedicating the spectrum for this specific service and adopting

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[12] CEMA would offer its resources to lead an Advisory Committee on this subject, if the Commission determines the creation of that is appropriate.

the technical standards to be deployed, the Commission should auction the ensembles, market-by-market to potential licensees.

CEMA believes that the guidelines set forth above establishes the nature of the service and the technical standards/system for MMBS deployment, thereby removing uncertainty in the market – to the benefit of the public, MMBS broadcasters and equipment/receiver manufacturers. As a new nationwide service, the regulatory paradigm for MMBS can be devised with administrative and interference-protection certainty while optimizing the platform for a host of new services to the public. Further, a universal nationwide MMBS implementation has significantly greater appeal than a patchwork quilt of unrelated, un-interoperable, and non-transportable services developed on a regional or local basis. This also has the benefit of employing economies of scale with mass production of receivers and transmitting equipment, thereby lowering entry costs to broadcasters and the public.

Finally, this serves to maximize the value of the ensemble licenses to be auctioned. Since these auctions cannot be conducted until after the year 2001, this presents ample time to devise the MMBS, the system specification, and the required interference protection of existing TV stations during the transition. In addition, a bidder intending to "float" auction funds to the government, with five to six year's delay until a new (unspecified) service is deployed is unlikely. Auctions in the past have held a sense of urgency in order to meet U.S. government budget concerns, but this is not now so pressing with the improving U.S. economy and growing government budget surpluses.

CEMA has scheduled a "Discovery Group" meeting for September 1999 to further gauge interest in developing MMBS. The objectives of this meeting are to:

(1) explore the features, services, and technologies available to craft a new nationwide MMBS that integrates free terrestrial over-the-air broadcasting of high-quality multichannel audio and high-capacity data services intended for mobile reception use;

(2) determine the levels of interests of participants and the regulatory requirements to implement MMBS; and

(3) assess the means to integrate appropriate technologies and to develop standards supporting MMBS.

In this fashion, CEMA hopes to provide a forum to further develop these proposals and, as appropriate, develop a framework and structure to identify and propose venues for technology assessments and integration, standards development and regulatory options. Further information about this Discovery Group meeting will soon be placed on CEMA's web site.[13]

III. THE COMMISSION SHOULD NOT SUBJECT FUTURE MMBS LICENSEES TO PART 27 RULES.

In the NPRM, the Commission proposes to permit licensees to determine the services they will provide with their assigned spectrum and geographic areas, and to subject these licensees generally to Part 27 of the Commission's Rules which governs Wireless Communications Service ("WCS").[14] According to the Commission, because Part 27 was originally developed with an architecture designed to accommodate flexible use, it believes it

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13 *See* CEMA web site at "http://www.cemacity.org."

14 *See NPRM* at ¶ 10; ¶¶ 23-46 (licensing rules); ¶¶ 47-56 (operating rules); and ¶¶ 57-72 (technical rules).

provides an appropriate licensing framework for the common elements of regulation that are applicable to wireless and broadcast services alike.[15] CEMA respectfully disagrees.

Fundamentally, the Commission must establish rules that will ensure that participants in the auction for this new spectrum will succeed in realizing their intended use for the allocation. Under the Commission's tentative proposal, there is no guarantee what WCS providers will be compatible with each other. It is CEMA's position that services that resemble existing broadcast services should be subject to Part 73, rather than Part 27 Rules. The provision of MMBS, as described above, is not appropriately regulated by the framework of Part 27. Different services operating under Part 27 Rules will encounter issues of incompatibility, which, as the Commission is aware, has occurred in the past. For example, a coalition of WCS licensees had encountered tremendous problems implementing Satellite Digital Audio Radio Service ("SDARS") under Part 27 because SDARS was incompatible with other WCS uses. CEMA believes that imposing the uncertainties of a Part 27 requirement will only serve to deter investment in new communications services and systems or technology development.

In CEMA's view, the possibility that too broad an approach to flexibility in spectrum use may have the undesired effect of deterring those investments needed to provide communications services and encourage new technologies on the newly allocated spectrum. The potential sharing of this spectrum between broadcast service licensees and fixed and mobile wireless licensees, alone, complicate these issues. The Commission must make every effort to ensure that services operating under the selected regulatory framework are compatible with each other.

CEMA's position is also consistent with Section 303(y) of the Communications Act,[16] which forms the statutory basis for the Commission's Part 27 approach. Importantly, CEMA

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15 *See id.* at ¶ 10.

believes that the Commission cannot find it in the public interest to exclude the development of MMBS through the application of generic Part 27 rules that would open this spectrum to a variety of incompatible uses and preclude the development of a new, national mass media market.

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[16] 47 U.S.C. § 303(y).

IV. CONCLUSION

Given the foregoing, CEMA urges the Commission to designate the entire 36 MHz (746-764 MHz and 776-794 MHz bands) to create a terrestrial Mobile Multimedia Broadcast Service, consistent with the recommendations set forth herein, and not to impose Part 27 requirements on this new service.

Respectfully submitted,

Consumer Electronics
Manufacturers Association

By: G. Klein /BCB

Gary S. Klein
Vice President,
Government and Legal Affairs

Michael Petricone
Director, Technology Policy
Government and Legal Affairs

George Hanover
Staff Vice President
Technology & Standards

Ralph Justus
Director
Technology & Standards

2500 Wilson Boulevard
Arlington, Virginia 22201
(703) 907-7600

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APPENDIX A
(CEMA Filing in WT Docket No. 99-168)

Analysis of the technical merits of terrestrial gap-fillers supplementing DAR satellite broadcasting in the L-band and S-band frequency range

(21 May 1997)

Written by: **G. Chouinard,** P.Eng.
B. McLarnon, P.Eng.
R. Paiement, P.Eng.
L. Thibault, P.Eng.
R. Voyer, P.Eng.
J. Whitteker, Ph.D.

Radio Broadcast Technologies Research,
Communications Research Centre,
3701 Carling Ave., Ottawa, Ontario
CANADA K2H 2S8

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Executive summary

This study analyzes the technical merits of terrestrial gap-fillers to supplement the coverage of satellite Digital Audio Radio Broadcast Service (DARS) and analyzes the impact of the system carrier frequency in the range covering L-band (1452-1492 MHz) and S-band (2310-2360 MHz) on the characteristics of such systems. This analysis was done in the context of the provision of a seamless coverage for satellite broadcasting of DARS as stated in the report presented to the FCC by the DARS Pioneer's Preference Review Panel.

This report discusses the various technologies and implementation means available in trying to achieve seamless coverage from a satellite and the effectiveness and relative complexity of the implementation of terrestrial gap-fillers to complement satellite DARS systems as well as the impact of the operating frequency, in the range of 1452 MHz to 2360 MHz, on the overall system complexity. Summary results of this analysis include:

1. Sizable differences exist in propagation between L-band and S-band. First, a 4 dB disadvantage at S-band exists due to an increase in free-space loss. This 4 dB disadvantage adds to other losses from absorption by trees, diffraction over rooftops in urban area reception, along with increased reception variability. These extra losses occur to different extent in the satellite and terrestrial cases. Taking all factors into consideration, approximately 6 dB higher satellite transmitter power may be needed at S-band as compared to L-band to provide the same DAR service availability. In the case of the terrestrial propagation, which will apply to reception from the terrestrial repeaters, beyond the 4 dB disadvantage at S-band due to augmentation in free-space loss, a further 3 dB fade margin has to be included due to absorption by trees and diffraction and an additional 3 dB margin is needed to secure a 95% coverage availability due to the increased field strength variability at S-band. This would translate in an increase in transmit power of some 10 dB for typical reception from the terrestrial gap-fillers.

2. Deploying on-channel terrestrial gap-fillers is considered to be the only effective way to provide seamless coverage for vehicular reception in all practical environments. Channel characteristics are examined and shown to consist, for the mobile environment, of flat fading (shadowing, normally modeled by a Log-normal distribution) and frequency selective fading (multipath, modeled by a Rayleigh statistical distribution). Although terrestrial repeaters allow for filling the satellite coverage gaps created by blockage due to the excess power available, this is done at the cost of creating an exacerbated multipath channel environment due to the presence of active echoes created by these gap-fillers. Error detection and correction methods, robust digital modulation and adaptive mitigation techniques such as channel estimation and equalization or multi-carrier modulation are examined to address these new demanding channel conditions.

3. In the case of the multi-carrier modulation, the relationship between the number of carriers, their spacing, symbol duration, guard interval duration and signal bandwidth is analyzed as to their effect on performance. The carrier spacing determines the impact of Doppler spread interference which is linearly related to the operating frequency and the vehicle speed. Models comparing L-band and S-band coverage show that a larger number of terrestrial repeaters is needed at S-band as compared to L-band to cover a given area while still allowing service to vehicles moving at speeds up to 80 km/h in urban environment.

4. Single carrier modulation systems (as proposed by satellite DARS applicants) must also use terrestrial gap-fillers to effectively compensate for shadowing by buildings in dense urban areas even in the case where satellite diversity is proposed. The presence of these gap-fillers makes the channel more difficult to correct because of the range of excess delays created by the presence of these active echoes. Channel equalization techniques need to be used to correct for the resulting frequency selective fading in the channel. Considerations of complexity and reasonable channel overhead dedicated for the training of these equalizers limit their applicability to narrowband systems (e.g., 200 kHz bandwidth).

5. The impact of the carrier frequency is examined for the hybrid satellite/terrestrial DARS operation. For the case of the multi-carrier modulation, values are given for parameters such as the distance allowed between repeaters and the expected attenuation on the terrestrial path. These parameters are related to the linear scaling of the guard interval with respect to frequency to keep a constant robustness of the system against Doppler spread. Coverage exercises have demonstrated that, when omnidirectional terrestrial repeaters are used, 15 of these repeaters are needed at L-band to augment the satellite coverage over a given service area whereas 85 would be required at S-band (resulting in a factor of 5.7 in number of repeaters between the two bands). When optimal directional terrestrial repeaters are used, their number can be reduced to 4 to cover the same area at L-band whereas 11 directional repeaters are needed at S-band (for a factor of 2.75 between the two bands).

6. A qualitative assessment of the various elements that affect DARS systems performance indicates appropriate frequency ranges that can be used for a hybrid satellite/terrestrial DARS system to provide seamless coverage to areas such as full CONUS down to ¼ CONUS. Figure 7.1 summarizes this discussion in a graphical form and illustrates some of the trade-offs concerning the complexity of satellite and receivers systems as a function of the carrier frequency. Due to the complexity of this discussion, it is clear that further investigation would be required to clarify and quantify these trade-offs.